

CHAPTER 4

ROPE MANAGEMENT AND KNOTS

The rope is a vital piece of equipment to the mountaineer. When climbing, rappelling, or building various installations, the mountaineer must know how to properly utilize and maintain this piece of equipment. If the rope is not managed or maintained properly, serious injury may occur. This chapter discusses common rope terminology, management techniques, care and maintenance procedures, and knots.

SECTION I. PREPARATION, CARE AND MAINTENANCE, INSPECTION, TERMINOLOGY

The service life of a rope depends on the frequency of use, applications (rappelling, climbing, rope installations), speed of descent, surface abrasion, terrain, climate, and quality of maintenance. Any rope may fail under extreme conditions (shock load, sharp edges, misuse).

4-1. PREPARATION

The mountaineer must select the proper rope for the task to be accomplished according to type, diameter, length, and tensile strength. It is important to prepare all ropes before departing on a mission. Avoid rope preparation in the field.

a. **Packaging.** New rope comes from the manufacturer in different configurations—boxed on a spool in various lengths, or coiled and bound in some manner. Precut ropes are usually packaged in a protective cover such as plastic or burlap. Do not remove the protective cover until the rope is ready for use.

b. **Securing the Ends of the Rope:** If still on a spool, the rope must be cut to the desired length. All ropes will fray at the ends unless they are bound or seared. Both static and dynamic rope ends are secured in the same manner. The ends must be heated to the melting point so as to attach the inner core strands to the outer sheath. By fusing the two together, the sheath cannot slide backward or forward. Ensure that this is only done to the ends of the rope. If the rope is exposed to extreme temperatures, the sheath could be weakened, along with the inner core, reducing overall tensile strength. The ends may also be dipped in enamel or lacquer for further protection.

4-2. CARE AND MAINTENANCE

The rope is a climber's lifeline. It must be cared for and used properly. These general guidelines should be used when handling ropes.

a. Do not step on or drag ropes on the ground unnecessarily. Small particles of dirt will be ground between the inner strands and will slowly cut them.

b. While in use, do not allow the rope to come into contact with sharp edges. Nylon rope is easily cut, particularly when under tension. If the rope must be used over a sharp edge, pad the edge for protection.

c. Always keep the rope as dry as possible. Should the rope become wet, hang it in large loops off the ground and allow it to dry. Never dry a rope with high heat or in direct sunlight.

d. Never leave a rope knotted or tightly stretched for longer than necessary. Over time it will reduce the strength and life of the rope.

e. Never allow one rope to continuously rub over or against another. Allowing rope-on-rope contact with nylon rope is extremely dangerous because the heat produced by the friction will cause the nylon to melt.

f. Inspect the rope before each use for frayed or cut spots, mildew or rot, or defects in construction (new rope).

g. The ends of the rope should be whipped or melted to prevent unraveling.

h. Do not splice ropes for use in mountaineering.

i. Do not mark ropes with paints or allow them to come in contact with oils or petroleum products. Some of these will weaken or deteriorate nylon.

j. Never use a mountaineering rope for any purpose except mountaineering.

k. Each rope should have a corresponding rope log (DA Form 5752-R, Rope History and Usage), which is also a safety record. It should annotate use, terrain, weather, application, number of falls, dates, and so on, and should be annotated each time the rope is used (Figure 4-1). DA Form 5752-R is authorized for local reproduction on 8 1/2- by 11-inch paper.

ROPE LOG (USAGE AND HISTORY)					UNIT ID MARKING	
For use of this form, see TC 90-6-1; the proponent agency is TRADOC.						
NPN 8455-73560366		DOCUMENT NUMBER W330SV 6189007		SERIAL NUMBER 6-6-6933		MFR LOT NUMBER 0620185115103
DATE OF MFR 08 NOV 96		ISSUE DATE 10 MAR 97		DATE IN SERVICE 4 APR 97		LENGTH 45 M (150 FT)
DIAMETER 11 mm (7/16 inch)		FIBER TYPE 6.6 NYLON		COLOR OD GREEN		CONSTRUCTION DYNAMIC KERMANTLE
INSPECT ROPE FOR DAMAGE OR EXCESSIVE WEAR EACH TIME IT IS DEPLOYED AND AGAIN AFTER EACH USE. IMMEDIATELY RETIRE ALL SUSPECT ROPES.						
DATE USED	LOCATION	TYPE OF USE	ROPE EXPOSURE	INSPECTOR'S INITIAL/DATE	ROPE CONDITION AND COMMENTS	
10 APR 97	YONAH MTN. GA	DIRECT AID CLIMB 5.7 R2	72°F CLEAR & DRY 5 MINUTE GRANITE	RCG 10 APR 97		
11 APR 97	YONAH MTN. GA	TOP ROPE BELAYED BALANCE CLIMB	76°F CLEAR & DRY SMOOTH GRANITE	STP 11 APR 97		
10-20 JUN 97	MT. MCKINLEY ALASKA	ROPE PARTY CLIMB - CLASS VI	25° - 54°F ONE ONLY W/ RAIN	CHX 22 JUN 97	ABRASION TO ROPE AT POINTS OF TIE-IN (ENDS & MIDDLE)	
25 JUL 97	LOOKING CURE NC	2-MAN PARTY ROCK CLIMB 5.9	97°F CLEAR & DRY GRANITE & QUARTZITE	ASD 27 JULY 97	SUSTAINED 115 FT LEADER FALL	
DA FORM 5752-R, MAY 89						
MANUFACTURER <u>G & S ROPE MANUFACTURERS</u> <u>711 STOUT BLVD, RANGERS, GA 12345</u>						
REVERSE OF DA FORM 5752-R, MAY 89						

Figure 4-1. Example of completed DA Form 5752-R.

l. Never subject the rope to high heat or flame. This will significantly weaken it.

m. All ropes should be washed periodically to remove dirt and grit, and rinsed thoroughly. Commercial rope washers are made from short pieces of modified pipe that connect to any faucet. Pinholes within the pipe force water to circulate around and scrub the rope as you slowly feed it through the washer. Another method is to machine wash,

on a gentle cycle, in cold water with a nylon safe soap, never bleach or harsh cleansers. Ensure that only front loading washing machine are used to wash ropes.

n. Ultraviolet radiation (sunlight) tends to deteriorate nylon over long periods of time. This becomes important if rope installations are left in place over a number of months.

o. When not in use, ropes should be loosely coiled and hung on wooden pegs rather than nails or other metal objects. Storage areas should be relatively cool with low humidity levels to prevent mildew or rotting. Rope may also be loosely stacked and placed in a rope bag and stored on a shelf. Avoid storage in direct sunlight, as the ultraviolet radiation will deteriorate the nylon over long periods

4-3. INSPECTION

Ropes should be inspected before and after each use, especially when working around loose rock or sharp edges.

a. Although the core of the kernmantle rope cannot be seen, it is possible to damage the core without damaging the sheath. Check a kernmantle rope by carefully inspecting the sheath before and after use while the rope is being coiled. When coiling, be aware of how the rope feels as it runs through the hands. Immediately note and tie off any lumps or depressions felt.

b. Damage to the core of a kernmantle rope usually consists of filaments or yarn breakage that results in a slight retraction. If enough strands rupture, a localized reduction in the diameter of the rope results in a depression that can be felt or even seen.

c. Check any other suspected areas further by putting them under tension (the weight of one person standing on a Prusik tensioning system is about maximum). This procedure will emphasize the lump or depression by separating the broken strands and enlarging the dip. If a noticeable difference in diameter is obvious, retire the rope immediately.

d. Many dynamic kernmantle ropes are quite soft. They may retain an indentation occasionally after an impact or under normal use without any trauma to the core. When damage is suspected, patiently inspect the sheath for abnormalities. Damage to the sheath does not always mean damage to the core. Inspect carefully.

4-4. TERMINOLOGY

When using ropes, understanding basic terminology is important. The terms explained in this section are the most commonly used in military mountaineering. (Figure 4-2, page 4-4, illustrates some of these terms.)

a. **Bight.** A bight of rope is a simple bend of rope in which the rope does not cross itself.

b. **Loop.** A loop is a bend of a rope in which the rope does cross itself.

c. **Half Hitch.** A half hitch is a loop that runs around an object in such a manner as to lock or secure itself.

d. **Turn.** A turn wraps around an object, providing 360-degree contact.

e. **Round Turn.** A round turn wraps around an object one and one-half times. A round turn is used to distribute the load over a small diameter anchor (3 inches or less). It may also be used around larger diameter anchors to reduce the tension on the knot, or provide added friction.

f. **Running End.** A running end is the loose or working end of the rope.

g. **Standing Part.** The standing part is the static, stationary, or nonworking end of the rope.

h. **Lay.** The lay is the direction of twist used in construction of the rope.

i. **Pigtail.** The pigtail (tail) is the portion of the running end of the rope between the safety knot and the end of the rope.

j. **Dress.** Dress is the proper arrangement of all the knot parts, removing unnecessary kinks, twists, and slack so that all rope parts of the knot make contact.

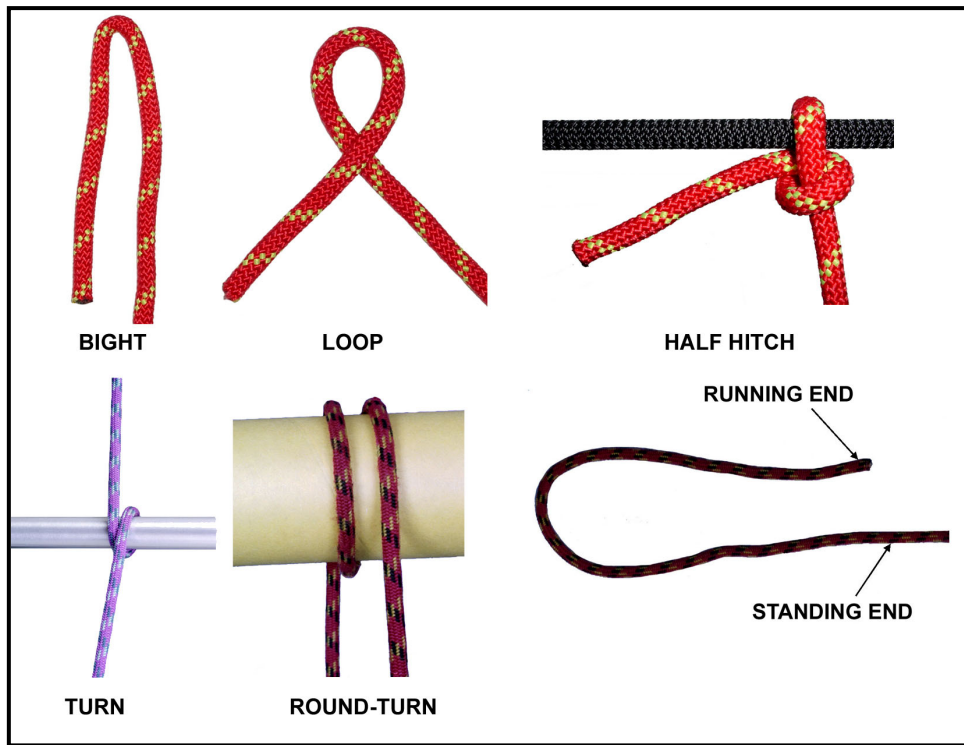


Figure 4-2. Examples of roping terminology.

Section II. COILING, CARRYING, THROWING

The ease and speed of rope deployment and recovery greatly depends upon technique and practice.

4-5. COILING AND CARRYING THE ROPE

Use the butterfly or mountain coil to coil and carry the rope. Each is easy to accomplish and results in a minimum amount of kinks, twists, and knots later during deployment.

a. **Mountain Coil.** To start a mountain coil, grasp the rope approximately 1 meter from the end with one hand. Run the other hand along the rope until both arms are outstretched. Grasping the rope firmly, bring the hands together forming a loop, which is laid in the hand closest to the end of the rope. This is repeated, forming uniform loops that run in a clockwise direction, until the rope is completely coiled. The rope may be given a 1/4 twist as each loop is formed to overcome any tendency for the rope to twist or form figure-eights.

(1) In finishing the mountain coil, form a bight approximately 30 centimeters long with the starting end of the rope and lay it along the top of the coil. Uncoil the last loop and, using this length of the rope, begin making wraps around the coil and the bight, wrapping toward the closed end of the bight and making the first wrap bind across itself so as to lock it into place. Make six to eight wraps to adequately secure the coil, and then route the end of the rope through the closed end of the bight. Pull the running end of the bight tight, securing the coil.

(2) The mountain coil may be carried either in the pack (by forming a figure eight), doubling it and placing it under the flap, or by placing it over the shoulder and under the opposite arm, slung across the chest. (Figure 4-3 shows how to coil a mountain coil.)



Figure 4-3. Mountain coil.

b. **Butterfly Coil.** The butterfly coil is the quickest and easiest technique for coiling (Figure 4-4).



Figure 4-4. Butterfly coil.

(1) **Coiling.** To start the double butterfly, grasp both ends of the rope and begin back feeding. Find the center of the rope forming a bight. With the bight in the left hand, grasp both ropes and slide the right hand out until there is approximately one arms length of rope. Place the doubled rope over the head, draping it around the neck and on top of the shoulders. Ensure that it hangs no lower than the waist. With the rest of the doubled rope in front of you, make doubled bights placing them over the head in the same manner as the first bight. Coil alternating from side to side (left to right, right to left) while maintaining equal-length bights. Continue coiling until approximately two arm-lengths of rope remain. Remove the coils from the neck and shoulders carefully, and hold the center in one hand. Wrap the two ends around the coils a minimum of three doubled wraps, ensuring that the first wrap locks back on itself.

(2) **Tie-off and Carrying.** Take a doubled bight from the loose ends of rope and pass it through the apex of the coils. Pull the loose ends through the doubled bight and dress it down. Place an overhand knot in the loose ends, dressing it down to the apex of the bight securing coils. Ensure that the loose ends do not exceed the length of the coils. In this configuration the coiled rope is secure enough for hand carrying or carrying in a rucksack, or for storage. (Figure 4-5 shows a butterfly coil tie-off.)



Figure 4-5. Butterfly coil tie-off.

c. **Coiling Smaller Diameter Rope.** Ropes of smaller diameters may be coiled using the butterfly or mountain coil depending on the length of the rope. Pieces 25 feet and shorter (also known as cordage, sling rope, utility cord) may be coiled so that they can be hung from the harness. Bring the two ends of the rope together, ensuring no kinks are in the rope. Place the ends of the rope in the left hand with the two ends facing the body. Coil the doubled rope in a clockwise direction forming 6- to 8-inch coils (coils may be larger depending on the length of rope) until an approximate 12-inch bight is left. Wrap that bight around the coil, ensuring that the first wrap locks on itself. Make three or more wraps. Feed the bight up through the bights formed at the top of the coil. Dress it down tightly. Now the piece of rope may be hung from a carabiner on the harness.

e. **Uncoiling, Back-feeding, and Stacking.** When the rope is needed for use, it must be uncoiled and stacked on the ground properly to avoid kinks and snarls.

(1) Untie the tie-off and lay the coil on the ground. Back-feed the rope to minimize kinks and snarls. (This is also useful when the rope is to be moved a short distance and

coiling is not desired.) Take one end of the rope in the left hand and run the right hand along the rope until both arms are outstretched. Next, lay the end of the rope in the left hand on the ground. With the left hand, re-grasp the rope next to the right hand and continue laying the rope on the ground.

(2) The rope should be laid or stacked in a neat pile on the ground to prevent it from becoming tangled and knotted when throwing the rope, feeding it to a lead climber, and so on. This technique can also be started using the right hand.

4-6. THROWING THE ROPE

Before throwing the rope, it must be properly managed to prevent it from tangling during deployment. The rope should first be anchored to prevent complete loss of the rope over the edge when it is thrown. Several techniques can be used when throwing a rope. Personal preference and situational and environmental conditions should be taken into consideration when determining which technique is best.

a. Back feed and neatly stack the rope into coils beginning with the anchored end of the rope working toward the running end. Once stacked, make six to eight smaller coils in the left hand. Pick up the rest of the larger coils in the right hand. The arm should be generally straight when throwing. The rope may be thrown underhanded or overhanded depending on obstacles around the edge of the site. Make a few preliminary swings to ensure a smooth throw. Throw the large coils in the right hand first. Throw up and out. A slight twist of the wrist, so that the palm of the hand faces up as the rope is thrown, allows the coils to separate easily without tangling. A smooth follow through is essential. When a slight tug on the left hand is felt, toss the six to eight smaller coils out. This will prevent the ends of the rope from becoming entangled with the rest of the coils as they deploy. As soon as the rope leaves the hand, the thrower should sound off with a warning of “ROPE” to alert anyone below the site.

b. Another technique may also be used when throwing rope. Anchor, back feed, and stack the rope properly as described above. Take the end of the rope and make six to eight helmet-size coils in the right hand (more may be needed depending on the length of the rope). Assume a “quarterback” simulated stance. Aiming just above the horizon, vigorously throw the rope overhanded, up and out toward the horizon. The rope must be stacked properly to ensure smooth deployment.

c. When windy weather conditions prevail, adjustments must be made. In a strong cross wind, the rope should be thrown angled into the wind so that it will land on the desired target. The stronger the wind, the harder the rope must be thrown to compensate.

SECTION III. KNOTS

All knots used by a mountaineer are divided into four classes: Class I—joining knots, Class II—anchor knots, Class III—middle rope knots, and Class IV—special knots. The variety of knots, bends, bights, and hitches is almost endless. These classes of knots are intended only as a general guide since some of the knots discussed may be appropriate in more than one class. The skill of knot tying can perish if not used and practiced. With experience and practice, knot tying becomes instinctive and helps the mountaineer in many situations.

4-7. SQUARE KNOT

The square knot is used to tie the ends of two ropes of equal diameter (Figure 4-6). It is a joining knot.

a. **Tying the Knot.**

- STEP 1. Holding one working end in each hand, place the working end in the right hand over the one in the left hand.
- STEP 2. Pull it under and back over the top of the rope in the left hand.
- STEP 3. Place the working end in the left hand over the one in the right hand and repeat STEP 2.
- STEP 4. Dress the knot down and secure it with an overhand knot on each side of the square knot.



Figure 4-6. Square knot.

b. **Checkpoints.**

- (1) There are two interlocking bights.
- (2) The running end and standing part are on the same side of the bight formed by the other rope.
- (3) The running ends are parallel to and on the same side of the standing ends with 4-inch minimum pig tails after the overhand safeties are tied.

4-8. FISHERMAN'S KNOT

The fisherman's knot is used to tie two ropes of the same or approximately the same diameter (Figure 4-7, page 4-10). It is a joining knot.

a. **Tying the Knot.**

- STEP 1. Tie an overhand knot in one end of the rope.

- STEP 2. Pass the working end of the other rope through the first overhand knot. Tie an overhand knot around the standing part of the first rope with the working end of the second rope.
- STEP 3. Tightly dress down each overhand knot and tightly draw the knots together.



Figure 4-7. Fisherman's knot.

b. Checkpoints.

- (1) The two separate overhand knots are tied tightly around the long, standing part of the opposing rope.
- (2) The two overhand knots are drawn snug.
- (3) Ends of rope exit knot opposite each other with 4-inch pigtails.

4-9. DOUBLE FISHERMAN'S KNOT

The double fisherman's knot (also called double English or grapevine) is used to tie two ropes of the same or approximately the same diameter (Figure 4-8). It is a joining knot.

a. Tying the Knot.

- STEP 1. With the working end of one rope, tie two wraps around the standing part of another rope.
- STEP 2. Insert the working end (STEP 1) back through the two wraps and draw it tight.
- STEP 3. With the working end of the other rope, which contains the standing part (STEPS 1 and 2), tie two wraps around the standing part of the other

rope (the working end in STEP 1). Insert the working end back through the two wraps and draw tight.

STEP 4. Pull on the opposing ends to bring the two knots together.



Figure 4-8. Double fisherman's knot.

b. Checkpoints.

- (1) Two double overhand knots securing each other as the standing parts of the rope are pulled apart.
- (2) Four rope parts on one side of the knot form two “x” patterns, four rope parts on the other side of the knot are parallel.
- (3) Ends of rope exit knot opposite each other with 4-inch pigtails.

4-10. FIGURE-EIGHT BEND

The figure-eight bend is used to join the ends of two ropes of equal or unequal diameter within 5-mm difference (Figure 4-9, page 4-12).

a. Tying the Knot.

- STEP 1. Grasp the top of a 2-foot bight.
- STEP 2. With the other hand, grasp the running end (short end) and make a 360-degree turn around the standing end.
- STEP 3. Place the running end through the loop just formed creating an in-line figure eight.

- STEP 4. Route the running end of the other rope back through the figure eight starting from the original rope's running end. Trace the original knot to the standing end.
- STEP 5. Remove all unnecessary twists and crossovers. Dress the knot down.

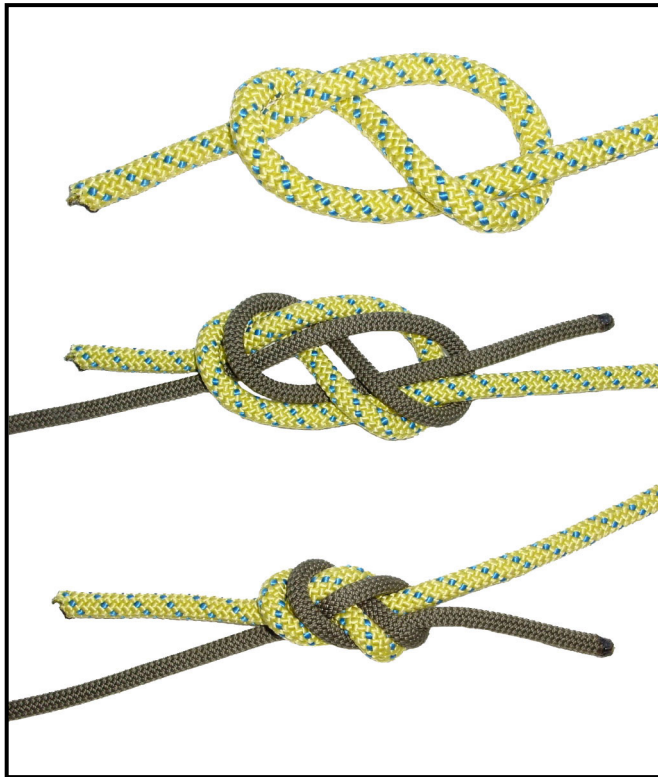


Figure 4-9. Figure-eight bend.

b. Checkpoints.

- (1) There is a figure eight with two ropes running side by side.
- (2) The running ends are on opposite sides of the knot.
- (3) There is a minimum 4-inch pigtail.

4-11. WATER KNOT

The water knot is used to attach two webbing ends (Figure 4-10). It is also called a ring bend, overhand retrace, or tape knot. It is used in runners and harnesses and is a joining knot.

a. Tying the Knot.

- STEP 1. Tie an overhand knot in one of the ends.
- STEP 2. Feed the other end back through the knot, following the path of the first rope in reverse.
- STEP 3. Draw tight and pull all of the slack out of the knot. The remaining tails must extend at least 4 inches beyond the knot in both directions.



Figure 4-10. Water knot.

b. Checkpoints.

- (1) There are two overhand knots, one retracing the other.
- (2) There is no slack in the knot, and the working ends come out of the knot in opposite directions.
- (3) There is a minimum 4-inch pigtail.

4-12. BOWLINE

The bowline is used to tie the end of a rope around an anchor. It may also be used to tie a single fixed loop in the end of a rope (Figure 4-11, page 4-14). It is an anchor knot.

a. Tying the Knot.

- STEP 1. Bring the working end of the rope around the anchor, from right to left (as the climber faces the anchor).
- STEP 2. Form an overhand loop in the standing part of the rope (on the climber's right) toward the anchor.
- STEP 3. Reach through the loop and pull up a bight.
- STEP 4. Place the working end of the rope (on the climber's left) through the bight, and bring it back onto itself. Now dress the knot down.
- STEP 5. Form an overhand knot with the tail from the bight.

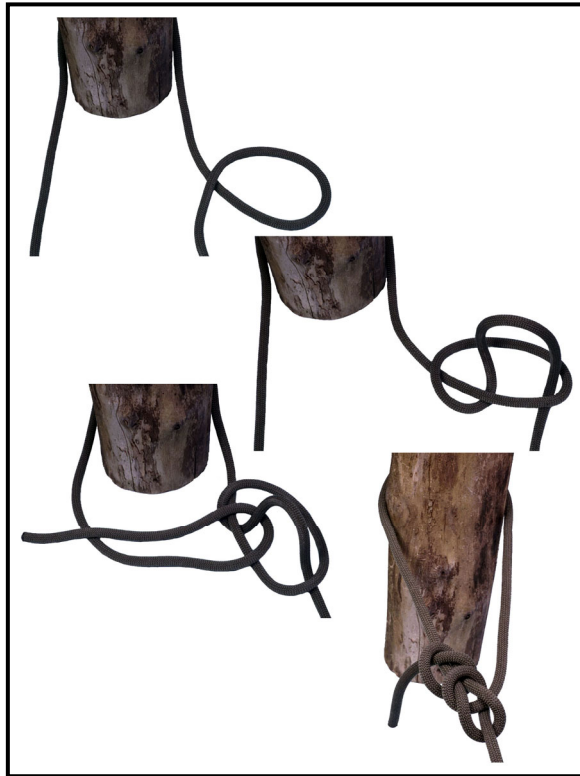


Figure 4-11. Bowline knot.

b. Checkpoints.

- (1) The bight is locked into place by a loop.
- (2) The short portion of the bight is on the inside and on the loop around the anchor (or inside the fixed loop).
- (3) There is a minimum 4-inch pigtail after tying the overhand safety.

4-13. ROUND TURN AND TWO HALF HITCHES

This knot is used to tie the end of a rope to an anchor, and it must have constant tension (Figure 4-12). It is an anchor knot.

a. Tying the Knot.

- STEP 1. Route the rope around the anchor from right to left and wrap down (must have two wraps in the rear of the anchor, and one in the front). Run the loop around the object to provide 360-degree contact, distributing the load over the anchor.
- STEP 2. Bring the working end of the rope left to right and over the standing part, forming a half hitch (first half hitch).
- STEP 3. Repeat STEP 2 (last half hitch has a 4 inch pigtail).
- STEP 4. Dress the knot down.

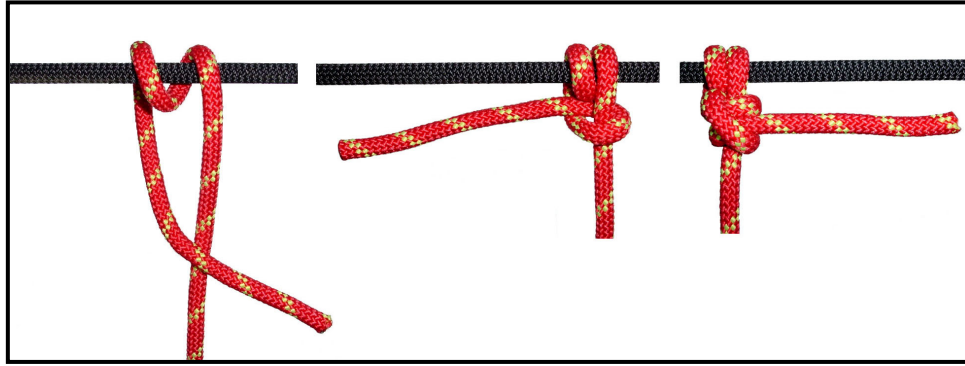


Figure 4-12. Round turn and two half hitches.

b. Checkpoints.

- (1) A complete round turn should exist around the anchor with no crosses.
- (2) Two half hitches should be held in place by a diagonal locking bar with no less than a 4-inch pigtail remaining.

4-14. FIGURE-EIGHT RETRACE (REROUTED FIGURE-EIGHT)

The figure-eight retrace knot produces the same result as a figure-eight loop. However, by tying the knot in a retrace, it can be used to fasten the rope to trees or to places where the loop cannot be used (Figure 4-13, page 4-16). It is also called a rerouted figure-eight and is an anchor knot.

a. Tying the Knot.

- STEP 1. Use a length of rope long enough to go around the anchor, leaving enough rope to work with.
- STEP 2. Tie a figure-eight knot in the standing part of the rope, leaving enough rope to go around the anchor. To tie a figure-eight knot form a loop in the rope, wrap the working end around the standing part, and route the working end through the loop. The finished knot is dressed loosely.
- STEP 3. Take the working end around the anchor point.
- STEP 4. With the working end, insert the rope back through the loop of the knot in reverse.
- STEP 5. Keep the original figure eight as the outside rope and retrace the knot around the wrap and back to the long-standing part.
- STEP 6. Remove all unnecessary twists and crossovers; dress the knot down.



Figure 4-13. Figure-eight retrace.

b. Checkpoints

- (1) A figure eight with a doubled rope running side by side, forming a fixed loop around a fixed object or harness.
- (2) There is a minimum 4-inch pigtail.

4-15. CLOVE HITCH

The clove hitch is an anchor knot that can be used in the middle of the rope as well as at the end (Figure 4-14). The knot must have constant tension on it once tied to prevent slipping. It can be used as either an anchor or middle of the rope knot, depending on how it is tied.

a. Tying the Knot.

(1) *Middle of the Rope.*

- STEP 1. Hold rope in both hands, palms down with hands together. Slide the left hand to the left from 20 to 25 centimeters.
- STEP 2. Form a loop away from and back toward the right.
- STEP 3. Slide the right hand from 20 to 25 centimeters to the right. Form a loop inward and back to the left hand.
- STEP 4. Place the left loop on top of the right loop. Place both loops over the anchor and pull both ends of the rope in opposite directions. The knot is tied.

(2) *End of the Rope.*

Note: For instructional purposes, assume that the anchor is horizontal.

- STEP 1. Place 76 centimeters of rope over the top of the anchor. Hold the standing end in the left hand. With the right hand, reach under the horizontal anchor, grasp the working end, and bring it inward.
- STEP 2. Place the working end of the rope over the standing end (to form a loop). Hold the loop in the left hand. Place the working end over the anchor from 20 to 25 centimeters to the left of the loop.
- STEP 3. With the right hand, reach down to the left hand side of the loop under the anchor. Grasp the working end of the rope. Bring the working end up and outward.
- STEP 4. Dress down the knot.

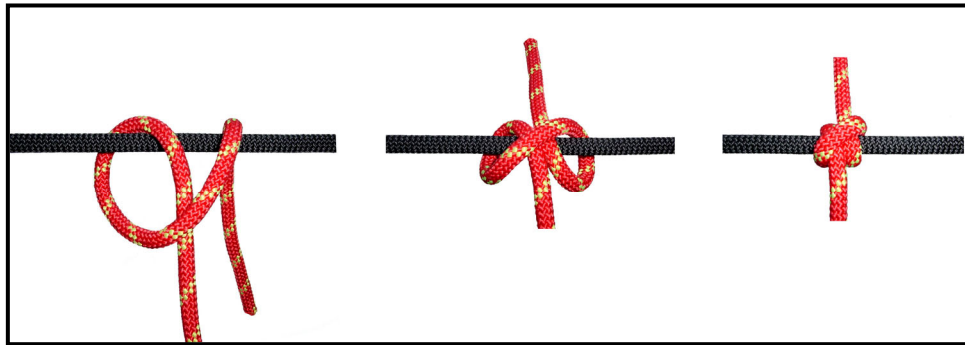


Figure 4-14. Clove hitch.

b. Checkpoints.

- (1) The knot has two round turns around the anchor with a diagonal locking bar.
- (2) The locking bar is facing 90 degrees from the direction of pull.
- (3) The ends exit 180 degrees from each other.
- (4) The knot has more than a 4-inch pigtail remaining.

4-16. WIREMAN'S KNOT

The wireman's knot forms a single, fixed loop in the middle of the rope (Figure 4-15, page 4-18). It is a middle rope knot.

a. Tying the Knot.

- STEP 1. When tying this knot, face the anchor that the tie-off system will be tied to. Take up the slack from the anchor, and wrap two turns around the left hand (palm up) from left to right.
- STEP 2. A loop of 30 centimeters is taken up in the second round turn to create the fixed loop of the knot.
- STEP 3. Name the wraps from the palm to the fingertips: heel, palm, and fingertip.
- STEP 4. Secure the palm wrap with the right thumb and forefinger, and place it over the heel wrap.
- STEP 5. Secure the heel wrap and place it over the fingertip wrap.
- STEP 6. Secure the fingertip wrap and place it over the palm wrap.
- STEP 7. Secure the palm wrap and pull up to form a fixed loop.

- STEP 8. Dress the knot down by pulling on the fixed loop and the two working ends.
- STEP 9. Pull the working ends apart to finish the knot.

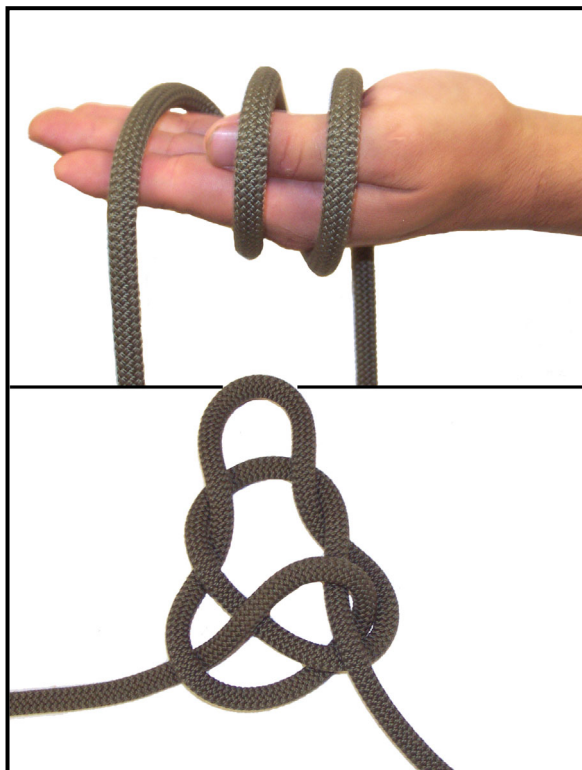


Figure 4-15. Wireman's knot.

b. Checkpoints.

- (1) The completed knot should have four separate bights locking down on themselves with the fixed loop exiting from the top of the knot and laying toward the near side anchor point.
- (2) Both ends should exit opposite each other without any bends.

4-17. DIRECTIONAL FIGURE-EIGHT

The directional figure-eight knot forms a single, fixed loop in the middle of the rope that lays back along the standing part of the rope (Figure 4-16). It is a middle rope knot.

a. Tying the Knot.

- STEP 1. Face the far side anchor so that when the knot is tied, it lays inward.
- STEP 2. Lay the rope from the far side anchor over the left palm. Make one wrap around the palm.
- STEP 3. With the wrap thus formed, tie a figure-eight knot around the standing part that leads to the far side anchor.
- STEP 4. When dressing the knot down, the tail and the bight must be together.

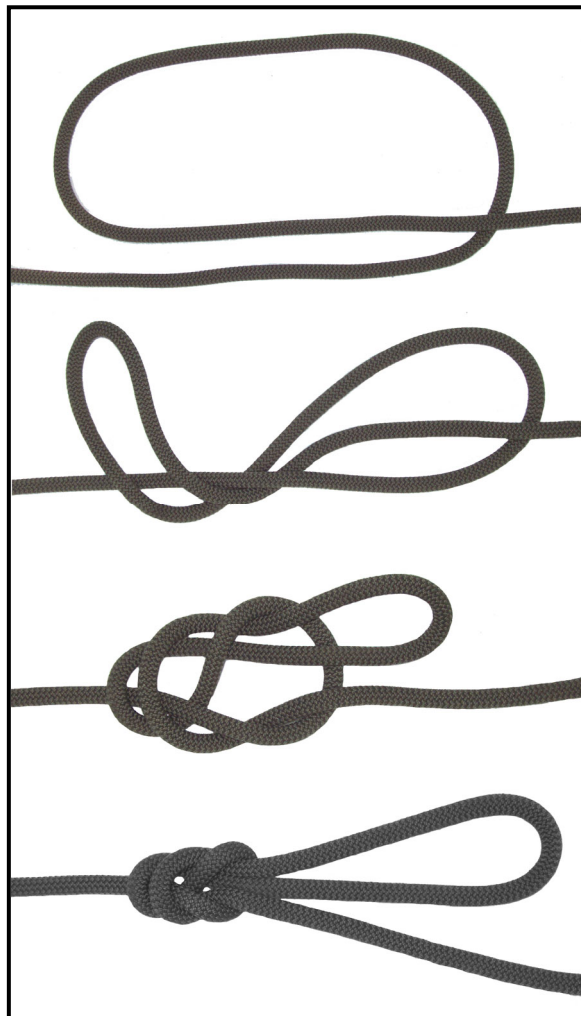


Figure 4-16. Directional figure-eight.

b. Checkpoints.

- (1) The loop should be large enough to accept a carabiner but no larger than a helmet-size loop.
- (2) The tail and bight must be together.
- (3) The figure eight is tied tightly.
- (4) The bight in the knot faces back toward the near side.

4-18. BOWLINE-ON-A-BIGHT (TWO-LOOP BOWLINE)

The bowline-on-a-bight is used to form two fixed loops in the middle of a rope (Figure 4-17, page 4-20). It is a middle rope knot.

a. Tying the Knot.

- STEP 1. Form a bight in the rope about twice as long as the finished loops will be.
- STEP 2. Tie an overhand knot on a bight.
- STEP 3. Hold the overhand knot in the left hand so that the bight is running down and outward.

- STEP 4. Grasp the bight with the right hand; fold it back over the overhand knot so that the overhand knot goes through the bight.
- STEP 5. From the end (apex) of the bight, follow the bight back to where it forms the cross in the overhand knot. Grasp the two ropes that run down and outward and pull up, forming two loops.
- STEP 6. Pull the two ropes out of the overhand knot and dress the knot down.
- STEP 7. A final dress is required: grasp the ends of the two fixed loops and pull, spreading them apart to ensure the loops do not slip.



Figure 4-17. Bowline-on-a-bight.

b. Checkpoints.

- (1) There are two fixed loops that will not slip.
- (2) There are no twists in the knot.
- (3) A double loop is held in place by a bight.

4-19. TWO-LOOP FIGURE-EIGHT

The two-loop figure-eight is used to form two fixed loops in the middle of a rope (Figure 4-18.) It is a middle rope knot.

a. Tying the Knot.

- STEP 1. Using a doubled rope, form an 18-inch bight in the left hand with the running end facing to the left.
- STEP 2. Grasp the bight with the right hand and make a 360-degree turn around the standing end in a counterclockwise direction.

- STEP 3. With the working end, form another bight and place that bight through the loop just formed in the left hand.
- STEP 4. Hold the bight with the left hand, and place the original bight (moving toward the left hand) over the knot.
- STEP 5. Dress the knot down.

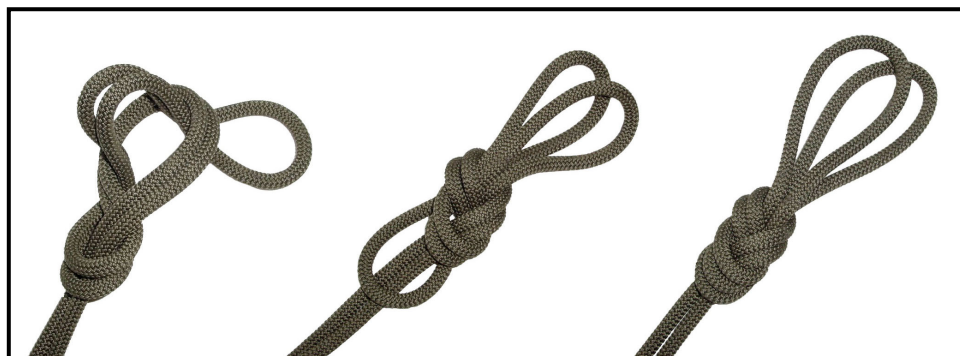


Figure 4-18. Two-loop figure-eight.

b. Checkpoints.

- (1) There is a double figure-eight knot with two loops that share a common locking bar.
- (2) The two loops must be adjustable by means of a common locking bar.
- (3) The common locking bar is on the bottom of the double figure-eight knot.

4-20. FIGURE-EIGHT LOOP (FIGURE-EIGHT-ON-A-BIGHT)

The figure-eight loop, also called the figure-eight-on-a-bight, is used to form a fixed loop in a rope (Figure 4-19). It is a middle of the rope knot.

a. Tying the Knot.

- STEP 1. Form a bight in the rope about as large as the diameter of the desired loop.
- STEP 2. With the bight as the working end, form a loop in rope (standing part).
- STEP 3. Wrap the working end around the standing part 360 degrees and feed the working end through the loop. Dress the knot tightly.

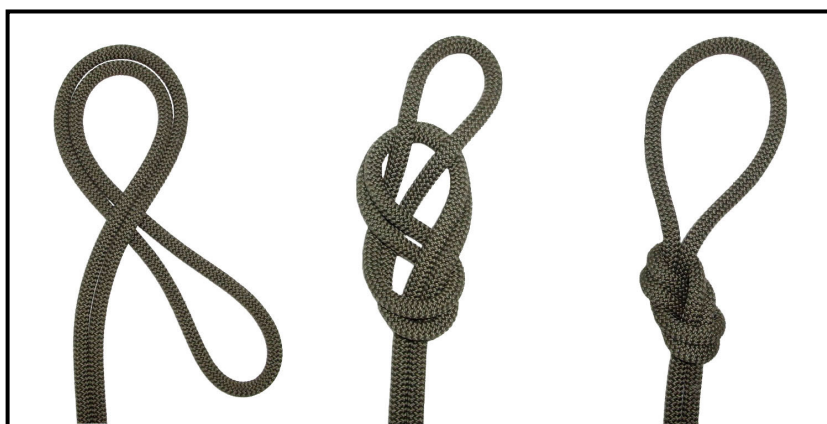


Figure 4-19. Figure-eight loop.

b. Checkpoints.

- (1) The loop is the desired size.
- (2) The ropes in the loop are parallel and do not cross over each other.
- (3) The knot is tightly dressed.

4-21. PRUSIK KNOT

The Prusik knot is used to put a moveable rope on a fixed rope such as a Prusik ascent or a tightening system. This knot can be tied as a middle or end of the rope Prusik. It is a specialty knot.

a. Tying the Knot.

(1) ***Middle-of-the-Rope Prusik.*** The middle-of-the-rope Prusik knot can be tied with a short rope to a long rope as follows (Figure 4-20.):

- STEP 1. Double the short rope, forming a bight, with the working ends even. Lay it over the long rope so that the closed end of the bight is 12 inches below the long rope and the remaining part of the rope (working ends) is the closest to the climber; spread the working end apart.
- STEP 2. Reach down through the 12-inch bight. Pull up both of the working ends and lay them over the long rope. Repeat this process making sure that the working ends pass in the middle of the first two wraps. Now there are four wraps and a locking bar working across them on the long rope.
- STEP 3. Dress the wraps and locking bar down to ensure they are tight and not twisted. Tying an overhand knot with both ropes will prevent the knot from slipping during periods of variable tension.

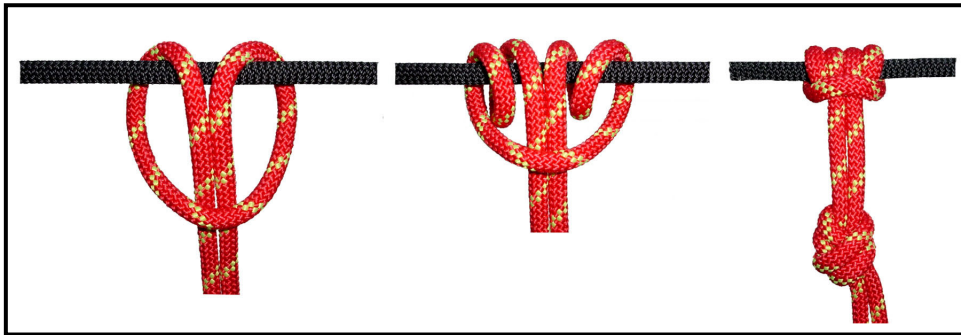


Figure 4-20. Middle-of-the-rope Prusik.

(2) ***End-of-the-Rope Prusik*** (Figure 4-21).

- STEP 1. Using an arm's length of rope, and place it over the long rope.
- STEP 2. Form a complete round turn in the rope.
- STEP 3. Cross over the standing part of the short rope with the working end of the short rope.
- STEP 4. Lay the working end under the long rope.
- STEP 5. Form a complete round turn in the rope, working back toward the middle of the knot.

- STEP 6. There are four wraps and a locking bar running across them on the long rope. Dress the wraps and locking bar down. Ensure they are tight, parallel, and not twisted.
- STEP 7. Finish the knot with a bowline to ensure that the Prusik knot will not slip out during periods of varying tension.

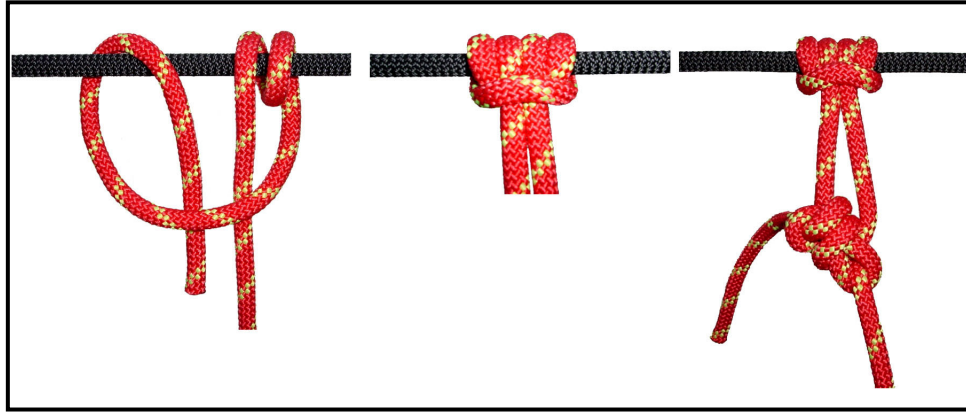


Figure 4-21. End-of-the-rope Prusik knot.

b. Checkpoints.

- (1) Four wraps with a locking bar.
- (2) The locking bar faces the climber.
- (3) The knot is tight and dressed down with no ropes twisted or crossed.
- (4) Other than a finger Prusik, the knot should contain an overhand or bowline to prevent slipping.

4-22. BACHMAN KNOT

The Bachman knot provides a means of using a makeshift mechanized ascender (Figure 4-22, page 4-24). It is a specialty knot.

a. Tying the Knot.

- STEP 1. Find the middle of a utility rope and insert it into a carabiner.
- STEP 2. Place the carabiner and utility rope next to a long climbing rope.
- STEP 3. With the two ropes parallel from the carabiner, make two or more wraps around the climbing rope and through the inside portion of the carabiner.

Note: The rope can be tied into an etrier (stirrup) and used as a Prusik-friction principle ascender.

b. Checkpoints.

- (1) The bight of the climbing rope is at the top of the carabiner.
- (2) The two ropes run parallel without twisting or crossing.
- (3) Two or more wraps are made around the long climbing rope and through the inside portion of the carabiner.

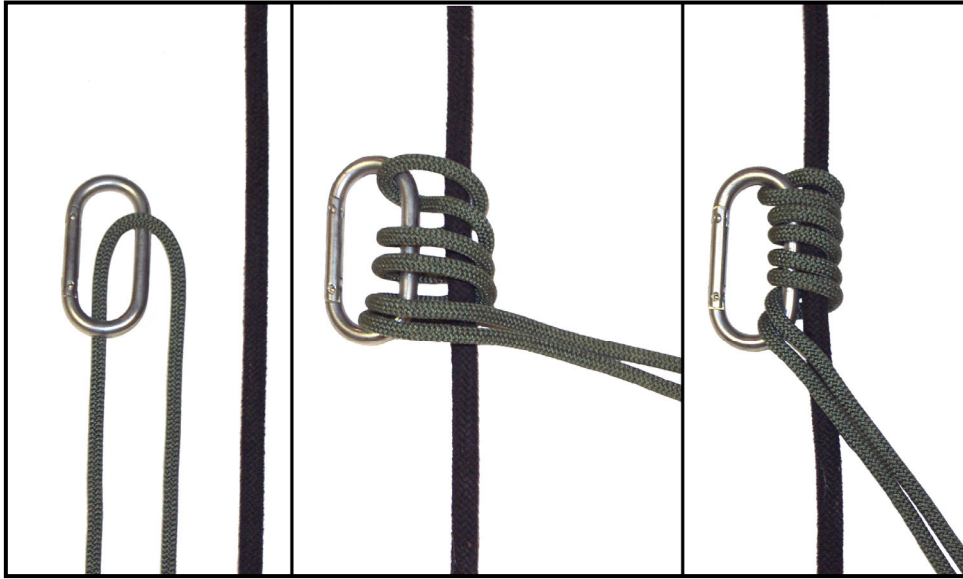


Figure 4-22. Bachman knot.

4-23. BOWLINE-ON-A-COIL

The bowline-on-a-coil is an expedient tie-in used by climbers when a climbing harness is not available (Figure 4-23). It is a specialty knot.

a. Tying the Knot.

- STEP 1. With the running end, place 3 feet of rope over your right shoulder. The running end is to the back of the body.
- STEP 2. Starting at the bottom of your rib cage, wrap the standing part of the rope around your body and down in a clockwise direction four to eight times.
- STEP 3. With the standing portion of the rope in your left hand, make a clockwise loop toward the body. The standing portion is on the bottom.
- STEP 4. Ensuring the loop does not come uncrossed, bring it up and under the coils between the rope and your body.
- STEP 5. Using the standing part, bring a bight up through the loop. Grasp the running end of the rope with the right hand. Pass it through the bight from right to left and back on itself.
- STEP 6. Holding the bight loosely, dress the knot down by pulling on the standing end.
- STEP 7. Safety the bowline with an overhand around the top, single coil. Then, tie an overhand around all coils, leaving a minimum 4-inch pigtail.

b. Checkpoints.

- (1) A minimum of four wraps, not crossed, with a bight held in place by a loop.
- (2) The loop must be underneath all wraps.
- (3) A minimum 4-inch pigtail after the second overhand safety is tied.
- (4) Must be centered on the mid-line of the body.

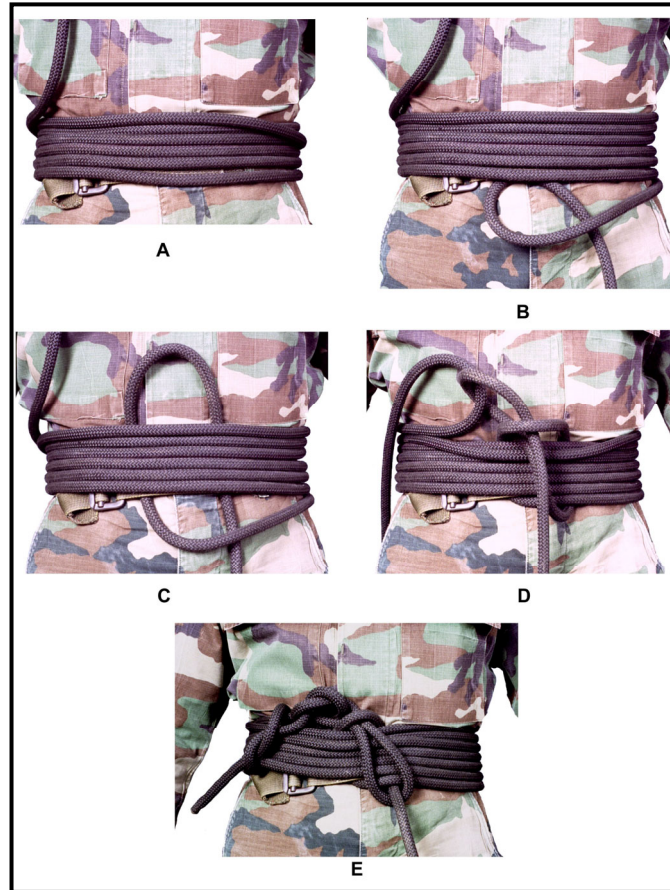


Figure 4-23. Bowline-on-a-coil.

4-24. THREE-LOOP BOWLINE

The three-loop bowline is used to form three fixed loops in the middle of a rope (Figure 4-24, page 4-26). It is used in a self-equalizing anchor system. It is a specialty knot.

a. Tying the Knot.

- STEP 1. Form an approximate 24-inch bight.
- STEP 2. With the right thumb facing toward the body, form a doubled loop in the standing part by turning the wrist clockwise. Lay the loops to the right.
- STEP 3. With the right hand, reach down through the loops and pull up a doubled bight from the standing part of the rope.
- STEP 4. Place the running end (bight) of the rope (on the left) through the doubled bight from left to right and bring it back on itself. Hold the running end loosely and dress the knot down by pulling on the standing parts.
- STEP 5. Safety it off with a doubled overhand knot.



Figure 4-24. Three-loop bowline.

b. Checkpoints.

- (1) There are two bights held in place by two loops.
- (2) The bights form locking bars around the standing parts.
- (3) The running end (bight) must be on the inside of the fixed loops.
- (4) There is a minimum 4-inch pigtail after the double overhand safety knot is tied.

4-25. FIGURE-EIGHT SLIP KNOT

The figure eight slip knot forms an adjustable bight in a rope (Figure 4-25). It is a specialty knot.

a. Tying the Knot.

- STEP 1. Form a 12-inch bight in the end of the rope.
- STEP 2. Hold the center of the bight in the right hand. Hold the two parallel ropes from the bight in the left hand about 12 inches up the rope.
- STEP 3. With the center of the bight in the right hand, twist two complete turns clockwise.
- STEP 4. Reach through the bight and grasp the long, standing end of the rope. Pull another bight (from the long standing end) back through the original bight.
- STEP 5. Pull down on the short working end of the rope and dress the knot down.
- STEP 6. If the knot is to be used in a transport tightening system, take the working end of the rope and form a half hitch around the loop of the figure eight knot.

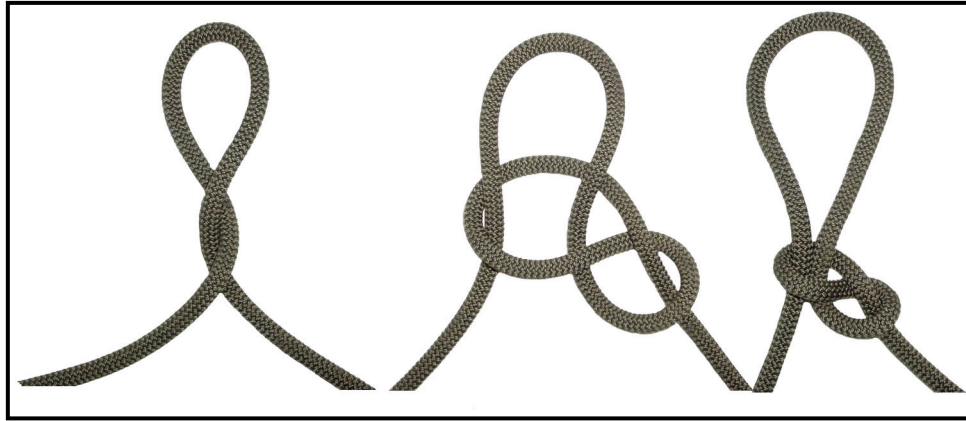


Figure 4-25. Figure-eight slip knot.

b. Checkpoints.

- (1) The knot is in the shape of a figure eight.
- (2) Both ropes of the bight pass through the same loop of the figure eight.
- (3) The sliding portion of the rope is the long working end of the rope.

4-26. TRANSPORT KNOT (OVERHAND SLIP KNOT/MULE KNOT)

The transport knot is used to secure the transport tightening system (Figure 4-26, page 4-28). It is simply an overhand slip knot.

a. Tying the Knot.

STEP 1. Pass the running end of the rope around the anchor point passing it back under the standing portion (leading to the far side anchor) forming a loop.

STEP 2. Form a bight with the running end of the rope. Pass over the standing portion and down through the loop and dress it down toward the anchor point.

STEP 3. Secure the knot by tying a half hitch around the standing portion with the bight.

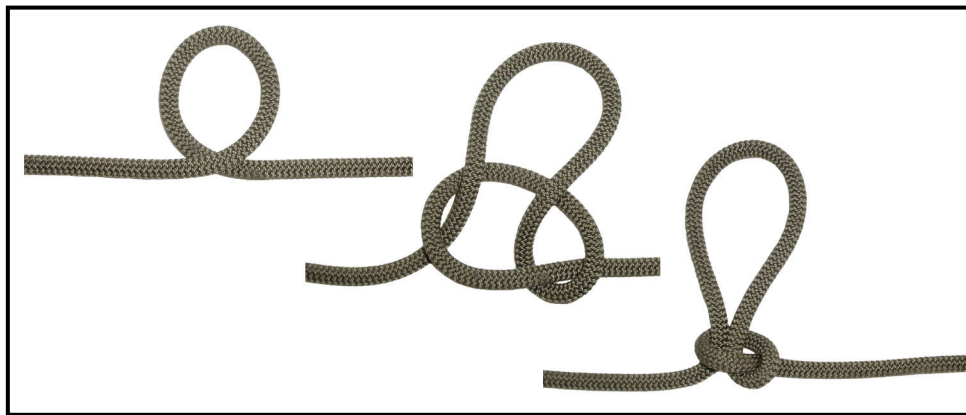


Figure 4-26. Transport knot.

b. Check Points.

- (1) There is a single overhand slip knot.

- (2) The knot is secured using a half hitch on a bight.
- (3) The bight is a minimum of 12 inches long.

4-27. KLEIMHIEST KNOT

The Kleimhiest knot provides a moveable, easily adjustable, high-tension knot capable of holding extremely heavy loads while being pulled tight (Figure 4-27). It is a special-purpose knot.

a. **Tying the Knot.**

- STEP 1. Using a utility rope or webbing offset the ends by 12 inches. With the ends offset, find the center of the rope and form a bight. Lay the bight over a horizontal rope.
- STEP 2. Wrap the tails of the utility rope around the horizontal rope back toward the direction of pull. Wrap at least four complete turns.
- STEP 3. With the remaining tails of the utility rope, pass them through the bight (see STEP 1).
- STEP 4. Join the two ends of the tail with a joining knot.
- STEP 5. Dress the knot down tightly so that all wraps are touching.

Note: Spectra should not be used for the Kleimhiest knot. It has a low melting point and tends to slip .

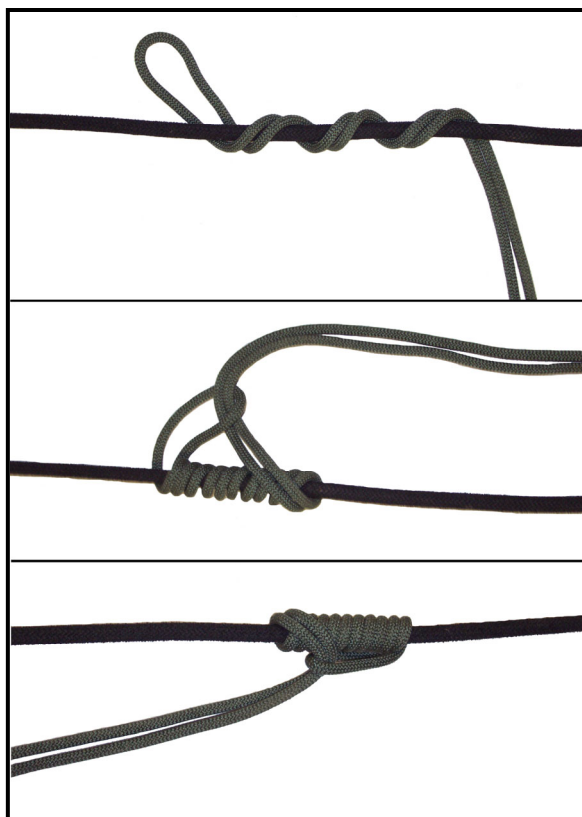


Figure 4-27. Kleimhiest knot.

b. Checkpoints.

- (1) The bight is opposite the direction of pull.
- (2) All wraps are tight and touching.
- (3) The ends of the utility rope are properly secured with a joining knot.

4-28. FROST KNOT

The frost knot is used when working with webbing (Figure 4-28, page 4-30). It is used to create the top loop of an etrier. It is a special-purpose knot.

a. Tying the Knot.

- STEP 1. Lap one end (a bight) of webbing over the other about 10 to 12 inches.
- STEP 2. Tie an overhand knot with the newly formed triple-strand webbing; dress tightly.



Figure 4-28. Frost knot.

b. Checkpoints.

- (1) The tails of the webbing run in opposite directions.
- (2) Three strands of webbing are formed into a tight overhand knot.
- (3) There is a bight and tail exiting the top of the overhand knot.

4-29. GIRTH HITCH

The girth hitch is used to attach a runner to an anchor or piece of equipment (Figure 4-29). It is a special-purpose knot.

a. Tying the Knot.

STEP 1: Form a bight.

STEP 2: Bring the runner back through the bight.

STEP 3: Cinch the knot tightly.

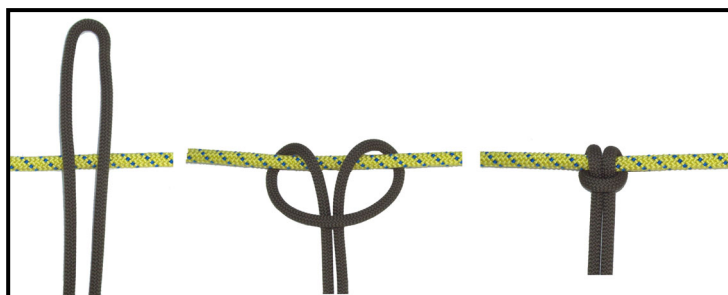


Figure 4-29. Girth hitch.

b. Checkpoint.

- (1) Two wraps exist with a locking bar running across the wraps.
- (2) The knot is dressed tightly.

4-30. MUNTER HITCH

The munter hitch, when used in conjunction with a pear-shaped locking carabiner, is used to form a mechanical belay (Figure 4-30).

a. Tying the Knot.

STEP 1. Hold the rope in both hands, palms down about 12 inches apart.

STEP 2. With the right hand, form a loop away from the body toward the left hand. Hold the loop with the left hand.

STEP 3. With the right hand, place the rope that comes from the bottom of the loop over the top of the loop.

STEP 4. Place the bight that has just been formed around the rope into the pear shaped carabiner. Lock the locking mechanism.

b. Check Points.

- (1) A bight passes through the carabiner, with the closed end around the standing or running part of the rope.
- (2) The carabiner is locked.



Figure 4-30. Munter hitch.

4-31. RAPPEL SEAT

The rappel seat is an improvised seat rappel harness made of rope (Figure 4-31, page 4-32). It usually requires a sling rope 14 feet or longer.

a. Tying the Knot.

- STEP 1. Find the middle of the sling rope and make a bight.
- STEP 2. Decide which hand will be used as the brake hand and place the bight on the opposite hip.
- STEP 3. Reach around behind and grab a single strand of rope. Bring it around the waist to the front and tie two overhands on the other strand of rope, thus creating a loop around the waist.
- STEP 4. Pass the two ends between the legs, ensuring they do not cross.
- STEP 5. Pass the two ends up under the loop around the waist, bisecting the pocket flaps on the trousers. Pull up on the ropes, tightening the seat.
- STEP 6. From rear to front, pass the two ends through the leg loops creating a half hitch on both hips.
- STEP 7. Bring the longer of the two ends across the front to the nonbrake hand hip and secure the two ends with a square knot safetied with overhand knots. Tuck any excess rope in the pocket below the square knot.



Figure 4-31. Rappel seat.

b. Check Points.

- (1) There are two overhand knots in the front.
- (2) The ropes are not crossed between the legs.
- (3) A half hitch is formed on each hip.
- (4) Seat is secured with a square knot with overhand safeties on the non-brake hand side.
- (5) There is a minimum 4-inch pigtail after the overhand safeties are tied.

4-32. GUARDE KNOT

The garde knot (ratchet knot, alpine clutch) is a special purpose knot primarily used for hauling systems or rescue (Figure 4-32). The knot works in only one direction and cannot be reversed while under load.

a. Tying the Knot.

- STEP 1. Place a bight of rope into the two anchored carabiners (works best with two like carabiners, preferably ovals).

- STEP 2. Take a loop of rope from the non-load side and place it down into the opposite carabiner so that the rope comes out between the two carabiners.

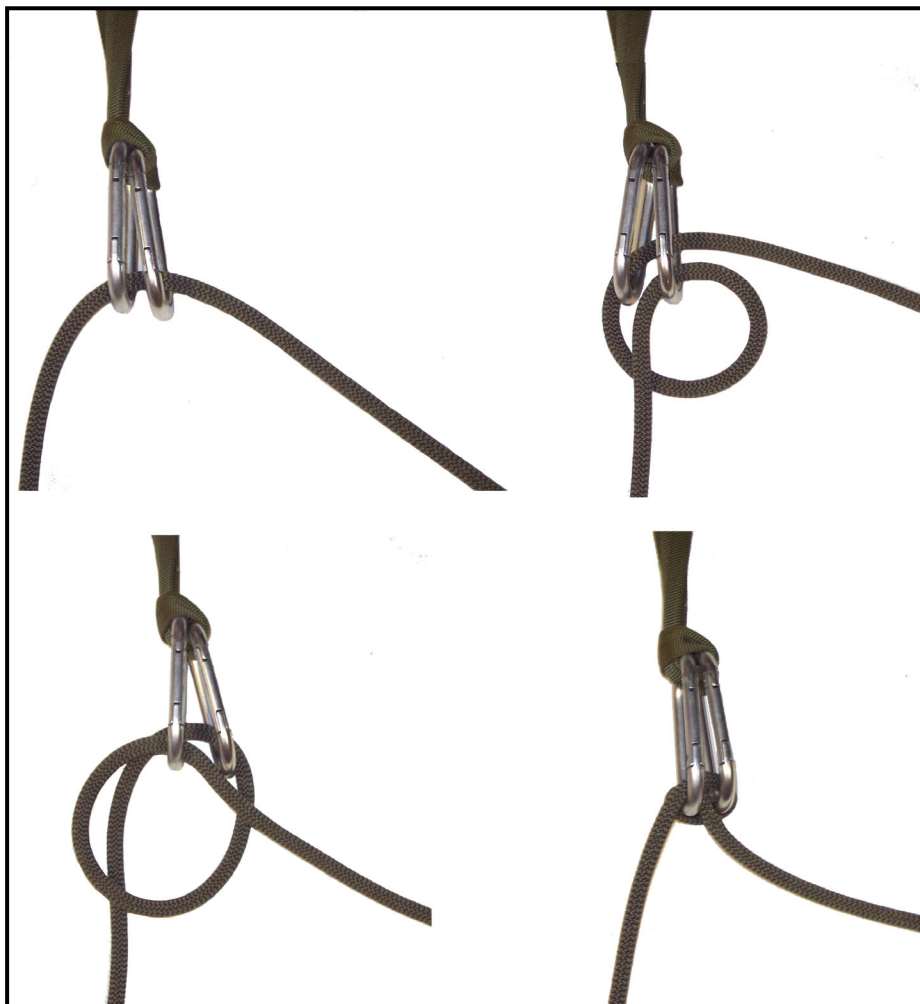


Figure 4-32. Guard knot.

b. Check Points.

- (1) When properly dressed, rope can only be pulled in one direction.
- (2) The knot will not fail when placed under load.